(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 February 2003 (27.02.2003)

PCT

(10) International Publication Number
WO 03/016714 A1

(51) International Patent Classification[7]: F03D 11/04, F03B 17/06

(21) International Application Number: PCT/GB02/03861

(22) International Filing Date: 21 August 2002 (21.08.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0120273.8 21 August 2001 (21.08.2001) GB

(71) Applicant *(for all designated States except US)*: IMPERIAL COLLEGE INNOVATIONS LIMITED [GB/GB]; Sherfield Building, Exhibition Road, London SW7 2AZ (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: COKER, Clive, Murray [GB/GB]; 1 Lyndhurst Close, Selborne Road, Croydon CR0 5LU (GB).

(74) Agent: BODEN, Keith, McMurray; Fry Heath & Spence, The Old College, 53 High Street, Horley, Surrey RH6 7BN (GB).

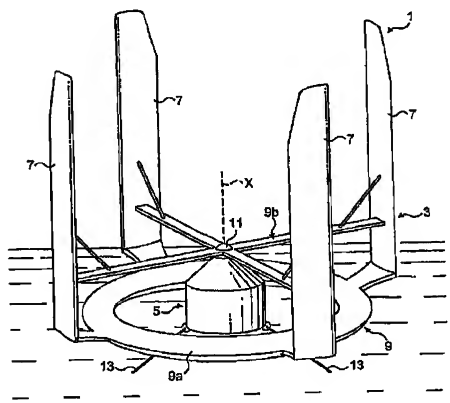
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: FLOATING VERTICAL-AXIS TURBINE



(57) Abstract: A floating vertical-axis turbine for offshore installation, comprising: a turbine (1) assembly (3) locatable at a surface of a body of water, wherein the turbine assembly comprises a fluid-rotatable structure rotatable about a substantially vertical rotation axis, the fluid-rotatable structure comprising at least one vane (7) spaced radially from the rotation axis, and a support member (9) for supporting the fluid-rotatable structure; and an energy-extraction device (5) coupled to the fluid-rotatable structure for extracting energy generated by rotation of the same.

WO 03/016714 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FLOATING VERTICAL-AXIS TURBINE

The present invention relates to a floating vertical-axis turbine for offshore installation, for example, on a lake or sea. The turbine of the present invention is to be known as the RingSail™ turbine.

Increasing energy costs, a finite supply of fossil fuels, such as oil, natural gas and coal, and the pollution caused by burning fossil fuels have prompted the search for efficient and clean energy alternatives to fossil fuels.

Alternative energy sources which have received widespread attention are wind-generated and water-generated energy sources. Indeed, in the UK, legislation exists which requires the utilization of such alternative energy sources, heightening the practicality and interest in the implementation of wind-generated and water-generated energy.

A particular advantage of wind-generated and water-generated energy is in being a renewable energy source which generates no pollution. Applications of energy so generated include driving electrical generators, pumps and compressors, such as used in desalinisation plant.

Another advantage of wind-generated and water-generated energy is that the energy can be generated locally at locations to which remotely-generated energy could not be easily transmitted, such as locations where no power line infrastructure exists. Examples of such locations include remote areas, such as offshore oil and gas rigs, where it would be uneconomic to install the necessary infrastructure, and on moving objects, such as ocean-going vessels, where permanent connection to a remote energy source would not be feasible.

Unfortunately, existing wind and water turbines have several drawbacks.

For wind turbines, the most significant of these drawbacks is that a typical turbine does not operate efficiently unless there is a relatively high wind speed, often as high as

twenty knots. Many areas of the world do not have sustained wind speeds of more than about six to ten knots, rendering most common turbines unsuitable for use as a reliable energy source. Offshore locations do provide a high wind speed environment, but the cost associated with installing existing wind turbines at offshore locations, often in deep water, is very high, since the turbines have to be fixed to the waterbed.

A further drawback of existing wind turbines is the high noise level produced by those turbines. The blade arrangement of those turbines is usually designed to maximize the revolution rate, resulting in a disturbing, audible noise level which varies in intensity and pitch with variations in the wind speed. Locating the wind turbines offshore would obviate this problem, but, as discussed hereinabove, the cost associated with installing existing wind turbines offshore is uneconomically high.

A yet further drawback of some existing wind turbines is the inability of those turbines to withstand high-speed winds, typically wind speeds greater than forty knots. Winds well in excess of forty knots occasionally occur in many areas of the world.

Examples of wind and water turbines are disclosed in DE-A-3224976, GB-A-2041458, GB-A-2092237, GB-A-2307722, GB-A-2337305, SU-A-1828939 and US-A-4045148.

It is an aim of the present invention to provide a floating vertical-axis turbine, in particular a floating vertical-axis wind turbine, for offshore installation, which is rugged, cost efficient, and provides high torque at low fluid flow speeds.

In one aspect the present invention provides a floating vertical-axis turbine for offshore installation, comprising: a turbine assembly locatable at a surface of a body of water, wherein the turbine assembly comprises a fluid-rotatable structure rotatable about a substantially vertical rotation axis, the fluid-rotatable structure comprising at least one vane spaced radially from the rotation axis, and a support member for supporting the fluid-rotatable structure; and an energy-extraction device coupled to the fluid-rotatable structure for extracting energy generated by rotation of the same.

In a preferred embodiment the turbine is in use tethered, preferably moored.

In one embodiment the support member comprises a buoyant member for supporting the fluid-rotatable structure at the surface of the body of water.

Preferably, the buoyant member is an annular member.

More preferably, the annular member is continuous.

In one preferred embodiment the buoyant member is an enclosed member.

In another preferred embodiment the buoyant member is an open-bottomed member enclosing in use a volume of air above the surface of the body of water.

In one embodiment the support member includes a plurality of hydrofoils acting in use to support the fluid-rotatable structure at the surface of the body of water on rotation of the same.

In another embodiment the turbine assembly further comprises a floating platform to which the support member is rotatably supported.

Preferably, the turbine further comprises: a further turbine assembly locatable at the surface of the body of water, wherein the further turbine assembly comprises a fluid-rotatable structure contra-rotatable about the rotation axis in the opposite sense to the fluid-rotatable structure of the first-mentioned turbine assembly, the fluid-rotatable structure of the further turbine assembly comprising at least one vane spaced radially from the rotation axis and a support member for supporting the same.

In one embodiment the fluid-rotatable structure of the further turbine assembly is coupled to the energy-extraction device for extracting energy generated by rotation of the same.

In another embodiment the turbine further comprises: a further energy-extraction device coupled to the fluid-rotatable structure of the further turbine assembly for extracting energy generated by rotation of the same.

In one embodiment the support member of the fluid-rotatable structure of the further turbine assembly comprises a buoyant member for supporting the fluid-rotatable structure of the further turbine assembly at the surface of the body of water.

Preferably, the buoyant member of the fluid-rotatable structure of the further turbine assembly is an annular member.

More preferably, the annular member is continuous.

In one preferred embodiment the buoyant member of the fluid-rotatable structure of the further turbine assembly is an enclosed member.

In another preferred embodiment the buoyant member of the fluid-rotatable structure of the further turbine assembly is an open-bottomed member enclosing in use a volume of air above the surface of the body of water.

In one embodiment the support member of the fluid-rotatable structure of the further turbine assembly includes a plurality of hydrofoils acting in use to support the fluid-rotatable structure of the further turbine assembly at the surface of the body of water on rotation of the same.

In another embodiment the platform is configured to support the support member of the fluid-rotatable structure of the further turbine assembly such that the fluid-rotatable structure of the further turbine assembly is rotatably supported thereon.

Preferably, any or each fluid-rotatable structure comprises a plurality of vanes, each spaced radially from the rotation axis.

More preferably, any or each vane comprises one of a sail, gutter, cup or blade, in particular an aerofoil.

In one embodiment each vane comprises a vertically-extending elongate member.

Preferably, the energy-extraction device comprises an energy-conversion device.

More preferably, the energy-conversion device comprises one of a generator, pump or compressor.

In one embodiment the turbine is a wind turbine and each vane of each fluid-rotatable structure extends upwardly into the atmosphere such as to be acted upon by a wind.

In another embodiment the turbine is a water turbine and each vane of each fluid-rotatable structure extends downwardly into the body of water such as to be acted upon by movement of the same.

In a further embodiment the turbine is a combined wind and water turbine, with each vane of the fluid-rotatable structure of the first-mentioned turbine assembly extending upwardly into the atmosphere such as to be acted upon by a wind and each vane of the fluid-rotatable structure of the further turbine assembly extending downwardly into the body of water such as to be acted upon by movement of the same.

In another aspect the present invention provides a floating vertical-axis turbine for offshore installation, comprising: a fluid-rotatable turbine assembly rotatable about a substantially vertical rotation axis and located in use at a surface of a body of water, wherein the turbine assembly comprises at least one vane spaced radially from the rotation axis such as to be acted upon by a fluid, and a buoyant, annular support member to which the at least one vane is fixed; and an energy-extraction device coupled to the turbine assembly for extracting energy generated by rotation of the same.

Preferably, the support member includes a plurality of hydrofoils acting in use to support the turbine assembly at the surface of the body of water on rotation of the same.

In a further aspect the present invention provides a floating vertical-axis wind turbine for offshore installation, comprising: a turbine assembly locatable at a surface of a body of water, wherein the turbine assembly comprises a wind-rotatable structure rotatable about a substantially vertical rotation axis and comprising at least one vane spaced radially from the rotation axis such as to be acted upon by a wind, and a buoyant, annular support member for supporting the wind-rotatable structure; and an energy-extraction device coupled to the wind-rotatable structure for extracting energy generated by rotation of the same.

The present invention also extends to a turbine system which includes the above-described turbine.

The present invention further extends to a turbine system, comprising: the above-described turbine; and at least one fluid deflector disposed upstream of the turbine and configured to increase the speed of the fluid in a region where the fluid acts on the at least one vane of any or each fluid-rotatable structure in providing a positive energy contribution and decrease the speed of the fluid in a region where the fluid does not act on the at least one vane of any or each fluid-rotatable structure to provide a positive energy contribution.

The present invention further provides an electrical power generation system comprising the above-described turbine system and a power line infrastructure connected thereto.

The present invention still further provides an electrical power generation system comprising the above-described turbine system and an energy storage device connected thereto.

The present invention yet further provides a pumping system comprising the above-described turbine system and a fluid line infrastructure connected thereto.

The turbine of the present invention is advantageously of low capital cost, in not requiring a ground or waterbed supported structure. In this regard, it should be

appreciated that low capital cost for a given energy output (installed cost per kW/h) is more significant than efficiency to commercialisation.

As a floating offshore installation, the turbine floats at the surface of a body of water, not unlike a sailing yacht, through buoyancy, the action of hydrofoils or a combination thereof. The turbine can be made using similar materials and construction methods as yachts and ocean-going vessels. Fibre glass or steel, as used in yachts and ocean-going vessels, are suitable materials for the construction of much of the turbine.

Where the support members of the fluid-rotatable structures are provided as continuous ring-shaped members which rotate about their own axis, the drag of the support members in the water is minimized. In effect, the rotating structures are similar to a slender yacht hull which has no bow or stern. Likewise, where the support members include hydrofoils which act to support the turbine, the drag of the support members in the water is minimized. The rotation of the support members in the water does result in some drag, but the resulting reduced efficiency is offset by the low-cost arrangement for supporting a large swept area. The energy efficiency of the design is less than that of a similar blade arrangement which is supported only by a central bearing and shaft, but the energy generated per unit cost is expected to be competitive where the lateral dimension of the turbine is of a size where the swept area matches that of the larger conventional horizontal-axis wind turbines.

Furthermore, the turbine of the present invention, in being a vertical-axis turbine, does not require a steering or positioning system to follow the flow direction of the fluid. This makes the design simpler than that of large horizontal-axis wind turbines, as widely used on wind farms.

Still furthermore, the ability of the turbine of the present invention to be increased in scale is greater than that of conventional horizontal-axis wind turbines. This is because there is no need for the construction of a supporting mast. The lateral dimension of the turbine could typically be as large as the section of a super tanker. At this scale, the lateral dimension of the turbine could be up to or greater than 1 km, with the height of the vanes being as high as materials would allow, at least of the scale of the largest

horizontal-axis wind turbine blades. In one embodiment the lateral dimension of the turbine is greater than about 100 m. In another embodiment the lateral dimension of the turbine is greater than about 500 m.

In one embodiment the hub of larger designs could make use of existing fixed offshore installations, such as disused oil or gas rigs, floating structures, such as oil storage/pipeline connection structures, one example being Brent Spar, or fixed offshore sites, such as small islands.

Preferred embodiments of the present invention will now be described hereinbelow by way of example only with reference to the accompanying drawings, in which:

Figure 1 illustrates a perspective view of a vertical-axis wind turbine in accordance with a first embodiment of the present invention;

Figure 2 illustrates a part-sectional elevational view of the turbine of Figure 1;

Figure 3 illustrates a plan view of the turbine of Figure 1;

Figure 4 illustrates a plan view of a turbine system incorporating the turbine of Figure 1;

Figure 5 illustrates a perspective view of a vertical-axis wind turbine in accordance with a second embodiment of the present invention;

Figure 6 illustrates a perspective view of a vertical-axis water turbine in accordance with a third embodiment of the present invention;

Figure 7 illustrates a part-sectional elevational view of the turbine of Figure 6;

Figure 8 illustrates an underneath view of the turbine of Figure 6;

Figure 9 illustrates a perspective view of a vertical-axis wind turbine in accordance with a fourth embodiment of the present invention; and

Figure 10 illustrates a perspective view of a combined wind and water turbine in accordance with a fifth embodiment of the present invention.

Figures 1 to 3 illustrate a wind turbine in accordance with a first embodiment of the present invention.

The wind turbine 1 is for offshore installation, in being configured to float, at least in the sense of being supported, on the surface of a body of water, typically a lake or sea.

The turbine 1 comprises a turbine assembly 3, in this embodiment a wind-rotatable structure, which is rotatable about a substantially vertical rotation axis X by a wind, and an energy-extraction device 5, in this embodiment an electrical generator, which is coupled to the turbine assembly 3 for extracting energy generated by rotation of the same. In alternative embodiments the energy-extraction device 5 could be a pump or compressor.

The turbine assembly 3 comprises a plurality of vanes 7, in this embodiment each spaced radially by the same distance from the rotation axis X, and a support member 9 for supporting the same. The construction techniques and materials used for fabricating the vanes 7 and the support member 9 may be conventional, as used in yacht construction and conventional horizontal-axis wind turbine blade construction.

In this embodiment the vanes 7 each comprise elongate, vertically-extending aerofoil blades. In an alternative embodiment the vanes 7 could comprise elongate, vertically-extending gutters.

In this embodiment the support member 9 comprises a buoyant, annular member 9a which is connected to the lower ends of each of the vanes 7 and acts both as a float for supporting the turbine 1 on the surface of the body of water and to transmit energy to the energy-extraction device 5, and a bracing assembly 9b which interconnects each of the vanes 7, here at substantially the mid-points thereof, such as to brace the same to prevent structural failure and present the same with such an orient as to extract energy. In this

embodiment the bracing assembly 9b provides a hub 11 at the rotation axis X to which the energy-extraction device 5 is coupled.

In this embodiment the annular member 9a comprises an enclosed rigid structure, preferably having the cross-section of the hull of a ship. In an alternative embodiment the annular member 9a could comprise an open-bottomed structure, such as an inverted U-shaped structure, which traps a volume of air therewithin above the surface of the body of water. In a further alternative embodiment the annular member 9a could be an inflatable member.

In this embodiment the energy-extraction device 5 is anchored by at least one tether 13 to the waterbed such as to fix the position of the energy-extraction device 5, both rotationally and to prevent drift.

In operation, a wind acting on the vanes 7 of the turbine assembly 3 causes the turbine assembly 3 to be rotated relative to the energy-extraction device 5, with the energy generated by rotation of the turbine assembly 3 being extracted by the energy-extraction device 5.

In one modification, the annular member 9a of the support member 9 could comprise lower and upper parts, with the lower part being a floating platform for supporting the turbine 1 on the surface of the body of water and the upper part being connected to the vanes 7 and rotatable relative to the lower part.

Figure 4 illustrates a turbine system which comprises the turbine 1 of the above-described first embodiment and a wind deflector unit 15 which is disposed upwind of the turbine 1. In this embodiment the wind deflector unit 15 comprises first and second wind deflectors 17a, 17b which are configured to increase the speed of the wind W in a region where the wind W acts on the vanes 7 of the turbine assembly 3 in providing a positive energy contribution and decrease the speed of the wind W in a region where the wind W does not act on the vanes 7 of the turbine assembly 3 to provide a positive energy contribution.

Figure 5 illustrates a wind turbine in accordance with a second embodiment of the present invention.

The turbine 1 of this embodiment represents a modification of the turbine 1 of the above-described first embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by like reference signs.

In this embodiment the turbine 1 comprises first and second contra-rotatable turbine assemblies 3a, 3b which are located on the surface of the body of water. Similarly to the first turbine assembly 3a, the second, further turbine assembly 3b is rotatable about the rotation axis X, but in the opposite sense to the first turbine assembly 3a. Again, similarly to the first turbine assembly 3a, the second turbine assembly 3b comprises a plurality of vanes 7, in this embodiment each spaced equally radially from the rotation axis X, and a support member 9 for supporting the same and transmitting energy to the energy-extraction device 5.

In this embodiment the second turbine assembly 3b is coupled to the same energy-extraction device 5 as the first turbine assembly 3a for extracting energy generated by rotation of the same.

In an alternative embodiment the turbine 1 could comprise first and second energy-extraction devices which are coupled to respective ones of the first and second turbine assemblies 3a, 3b for extracting energy generated by rotation of the same.

Figures 6 to 8 illustrate a water turbine in accordance with a third embodiment of the present invention.

The turbine 1 of this embodiment is of substantially identical construction to the wind turbine 1 of the above-described first embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like reference signs designating like parts.

The turbine 1 of this embodiment differs from that of the above-described first embodiment principally in being inverted such that the vanes 7 extend downwardly into the body of water, whereby the vanes 7 are acted upon by a flow of the water, such as the flow of an ocean current, tidal flow or river flow. The only other modification is that the at least one tether 13 is connected to the energy-extraction device 5 at the hub 11. Operation is the same as for the above-described first embodiment.

In one alternative embodiment the turbine 1 could include a plurality of energy-extraction devices 5 which are driven by a ring or gearwheel attached to the support member 9.

Figure 9 illustrates a wind turbine in accordance with a fourth embodiment of the present invention.

The turbine 1 of this embodiment is a modification of that of the above-described first embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by like reference signs.

The turbine 1 of this embodiment differs in that the annular member 9a of the support member 9 includes a plurality of hydrofoils 21 which are disposed thereabout, in this embodiment equi-spaced, and act to support the turbine 1 at the surface of the body of water on rotation of the same.

Figure 10 illustrates a combined wind and water turbine in accordance with a fifth embodiment of the present invention.

The turbine 1 of this embodiment represents a combination of the above-described first and third embodiments, in comprising a first, vertical-axis wind turbine assembly 3a of the same construction as the turbine assembly 3 of the wind turbine 1 of the first embodiment and a second, vertical-axis water turbine assembly 3b of the same construction as the water turbine 1 of the third embodiment, with each vane 7 of the first turbine assembly 3a extending upwardly into the atmosphere such as to be acted upon by

a wind and each vane 7 of the second turbine assembly 3b extending downwardly into the body of water such as to be acted upon by movement of the same. Operation is the same as for the above-described first and third embodiments.

In this embodiment the turbine 1 comprises first and second energy-extraction devices 5a, 5b which are coupled to respective ones of the turbine assemblies 3a, 3b for extracting energy generated by rotation of the same.

Finally, it will be understood that the present invention has been described in its preferred embodiments and can be modified in many different ways without departing from the scope of the invention as defined by the appended claims.

For example, the wind deflector unit 15 described hereinabove can be applied equally to the deflection of a water flow. Indeed, the turbine 1 of the above-described fifth embodiment could include both wind and water deflector units 15.

CLAIMS

1. A floating vertical-axis turbine for offshore installation, comprising:
a turbine assembly locatable at a surface of a body of water, wherein the turbine assembly comprises a fluid-rotatable structure rotatable about a substantially vertical rotation axis, the fluid-rotatable structure comprising at least one vane spaced radially from the rotation axis, and a support member for supporting the fluid-rotatable structure; and
an energy-extraction device coupled to the fluid-rotatable structure for extracting energy generated by rotation of the same.

2. The turbine of claim 1, wherein the turbine is in use tethered.

3. The turbine of claim 1 or 2, wherein the support member comprises a buoyant member for supporting the fluid-rotatable structure at the surface of the body of water.

4. The turbine of claim 3, wherein the buoyant member is an annular member.

5. The turbine of claim 4, wherein the annular member is continuous.

6. The turbine of any of claims 3 to 5, wherein the buoyant member is an enclosed member.

7. The turbine of any of claims 3 to 5, wherein the buoyant member is an open-bottomed member enclosing in use a volume of air above the surface of the body of water.

8. The turbine of any of claims 1 to 7, wherein the support member includes a plurality of hydrofoils acting in use to support the fluid-rotatable structure at the surface of the body of water on rotation of the same.

9. The turbine of claim 1 or 2, wherein the turbine assembly further comprises a floating platform to which the support member is rotatably supported.

10. The turbine of any of claims 1 to 9, further comprising:
a further turbine assembly locatable at the surface of the body of water, wherein the further turbine assembly comprises a fluid-rotatable structure contra-rotatable about the rotation axis in the opposite sense to the fluid-rotatable structure of the first-mentioned turbine assembly, the fluid-rotatable structure of the further turbine assembly comprising at least one vane spaced radially from the rotation axis, and a support member for supporting the fluid-rotatable structure of the further turbine assembly.

11. The turbine of claim 10, wherein the fluid-rotatable structure of the further turbine assembly is coupled to the energy-extraction device for extracting energy generated by rotation of the same.

12. The turbine of claim 10, further comprising:
a further energy-extraction device coupled to the fluid-rotatable structure of the further turbine assembly for extracting energy generated by rotation of the same.

13. The turbine of any of claims 10 to 12, wherein the support member of the fluid-rotatable structure of the further turbine assembly comprises a buoyant member for supporting the fluid-rotatable structure of the further turbine assembly at the surface of the body of water.

14. The turbine of claim 13, wherein the buoyant member of the fluid-rotatable structure of the further turbine assembly is an annular member.

15. The turbine of claim 14, wherein the annular member is continuous.

16. The turbine of any of claims 13 to 15, wherein the buoyant member of the fluid-rotatable structure of the further turbine assembly is an enclosed member.

17. The turbine of any of claims 13 to 15, wherein the buoyant member of the fluid-rotatable structure of the further turbine assembly is an open-bottomed member enclosing in use a volume of air above the surface of the body of water.

18. The turbine of any of claims 10 to 17, wherein the support member of the fluid-rotatable structure of the further turbine assembly includes a plurality of hydrofoils acting in use to support the fluid-rotatable structure of the further turbine assembly at the surface of the body of water on rotation of the same.

19. The turbine of any of claims 10 to 12 when appendant upon claim 9, wherein the platform is configured to support the support member of the fluid-rotatable structure of the further turbine assembly such that the fluid-rotatable structure of the further turbine assembly is rotatably supported thereon.

20. The turbine of any of claims 1 to 19, wherein any or each fluid-rotatable structure comprises a plurality of vanes, each spaced radially from the rotation axis.

21. The turbine of claim 20, wherein any or each vane comprises one of a sail, gutter, cup or blade, in particular an aerofoil.

22. The turbine of any of claims 1 to 21, wherein the energy-extraction device comprises an energy-conversion device.

23. The turbine of claim 22, wherein the energy-conversion device comprises one of a generator, pump or compressor.

24. The turbine of any of claims 1 to 23, wherein the turbine is a wind turbine and each vane of each fluid-rotatable structure extends upwardly into the atmosphere such as to be acted upon by a wind.

25. The turbine of any of claims 1 to 23, wherein the turbine is a water turbine and each vane of each fluid-rotatable structure extends downwardly into the body of water such as to be acted upon by movement of the same.

26. The turbine of any of claims 1 to 23 when appendant upon claim 10, wherein the turbine is a combined wind and water turbine, with each vane of the fluid-rotatable structure of the first-mentioned turbine assembly extending upwardly into the atmosphere such as to be acted upon by a wind and each vane of the fluid-rotatable structure of the further turbine assembly extending downwardly into the body of water such as to be acted upon by movement of the same.

27. A floating vertical-axis turbine for offshore installation, comprising:
a fluid-rotatable turbine assembly rotatable about a substantially vertical rotation axis and located in use at a surface of a body of water, wherein the turbine assembly comprises at least one vane spaced radially from the rotation axis such as to be acted upon by a fluid, and a buoyant, annular support member to which the at least one vane is fixed; and
an energy-extraction device coupled to the turbine assembly for extracting energy generated by rotation of the same.

28. The turbine of claim 27, wherein the support member includes a plurality of hydrofoils acting in use to support the turbine assembly at the surface of the body of water on rotation of the same.

29. A floating vertical-axis wind turbine for offshore installation, comprising:
a turbine assembly locatable at a surface of a body of water, wherein the turbine assembly comprises a wind-rotatable structure rotatable about a substantially vertical rotation axis and comprising at least one vane spaced radially from the rotation axis such as to be acted upon by a wind, and a buoyant, annular support member for supporting the wind-rotatable structure; and
an energy-extraction device coupled to the wind-rotatable structure for extracting energy generated by rotation of the same.

30. A turbine system including the turbine of any of claims 1 to 29.

31. A turbine system, comprising:

the turbine of any of claims 1 to 29; and

at least one fluid deflector disposed upstream of the turbine and configured to increase the speed of the fluid in a region where the fluid acts on the at least one vane of any or each fluid-rotatable structure in providing a positive energy contribution and decrease the speed of the fluid in a region where the fluid does not act on the at least one vane of any or each fluid-rotatable structure to provide a positive energy contribution.

32. An electrical power generation system comprising the turbine system of claim 30 or 31 and a power line infrastructure connected thereto.

33. An electrical power generation system comprising the turbine system of claim 30 or 31 and an energy storage device connected thereto.

34. A pumping system comprising the turbine system of claim 30 or 31 and a fluid line infrastructure connected thereto.

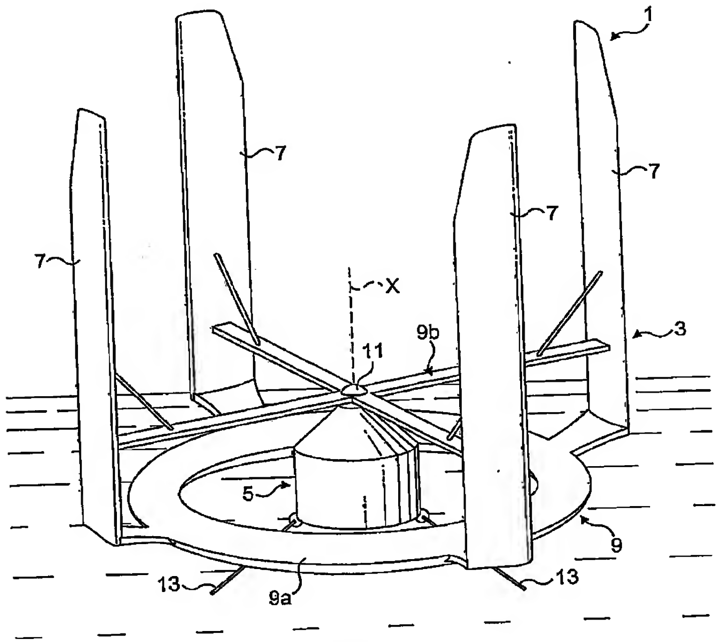


FIG. 1

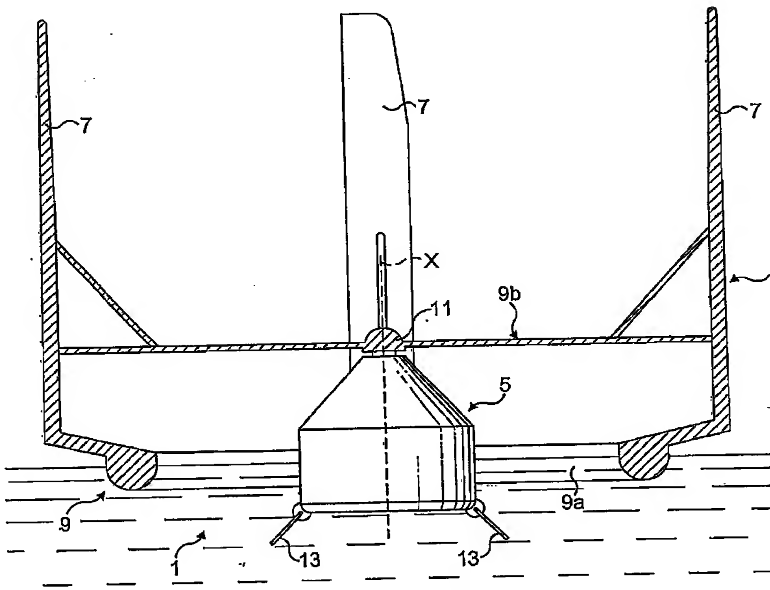


FIG. 2

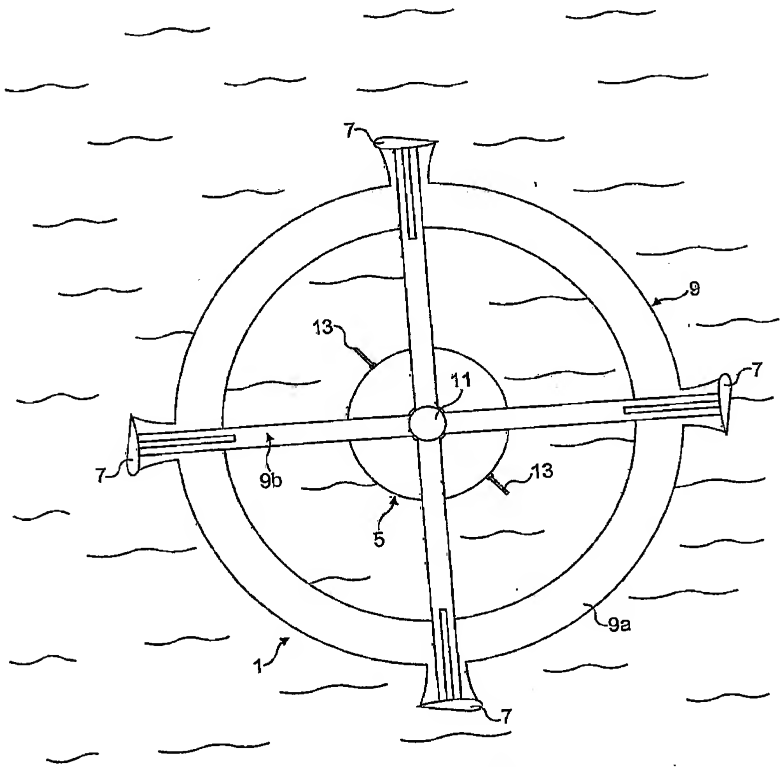


FIG. 3

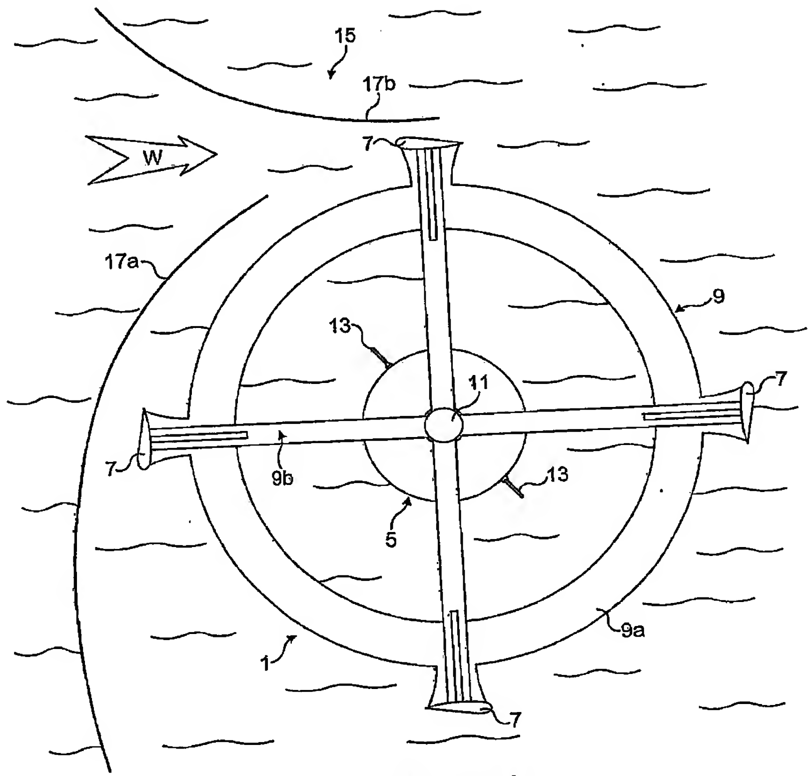


FIG. 4

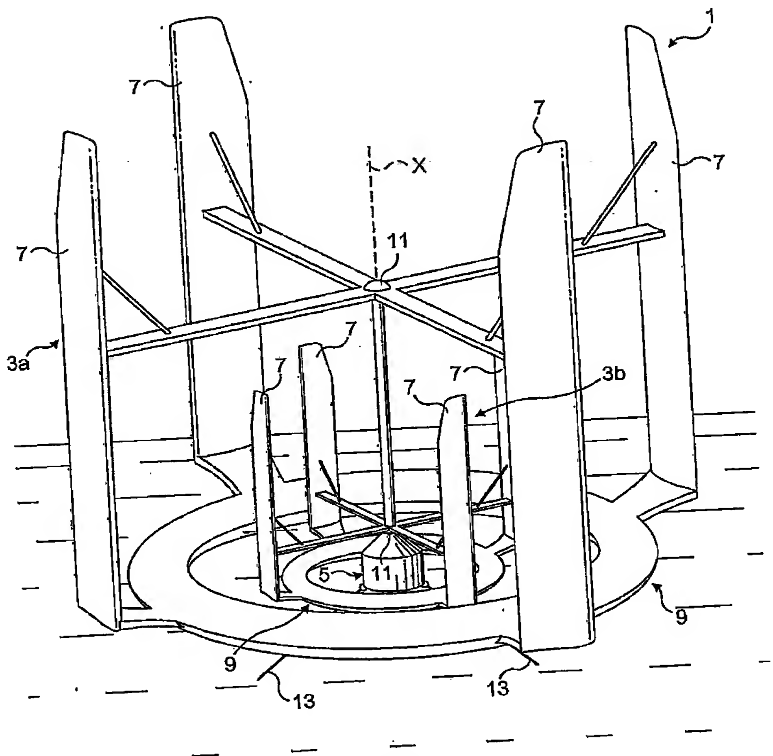


FIG. 5

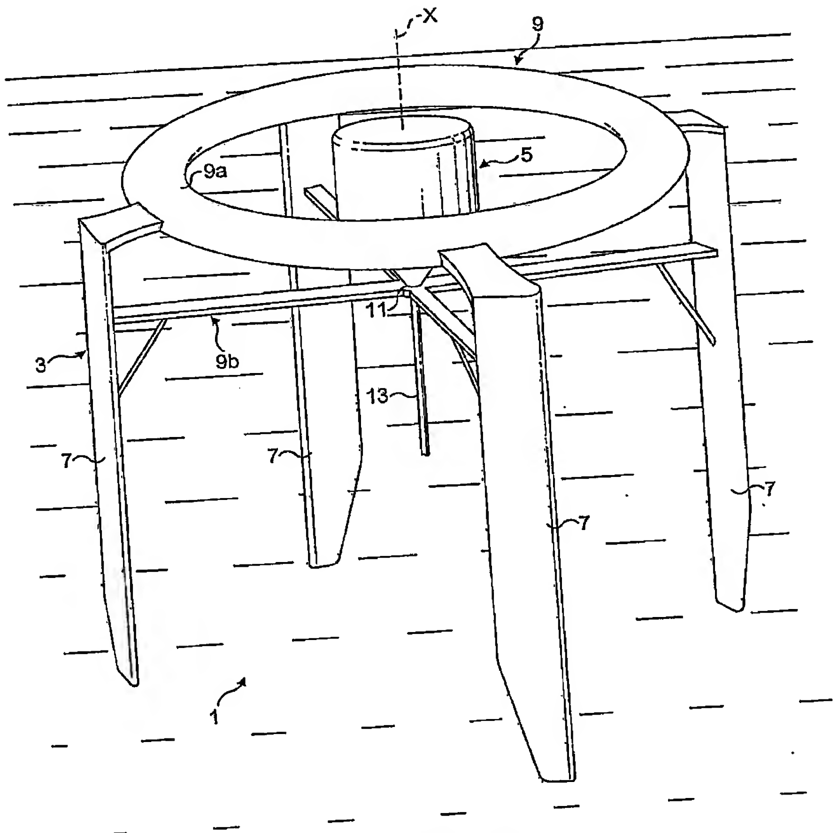


FIG. 6

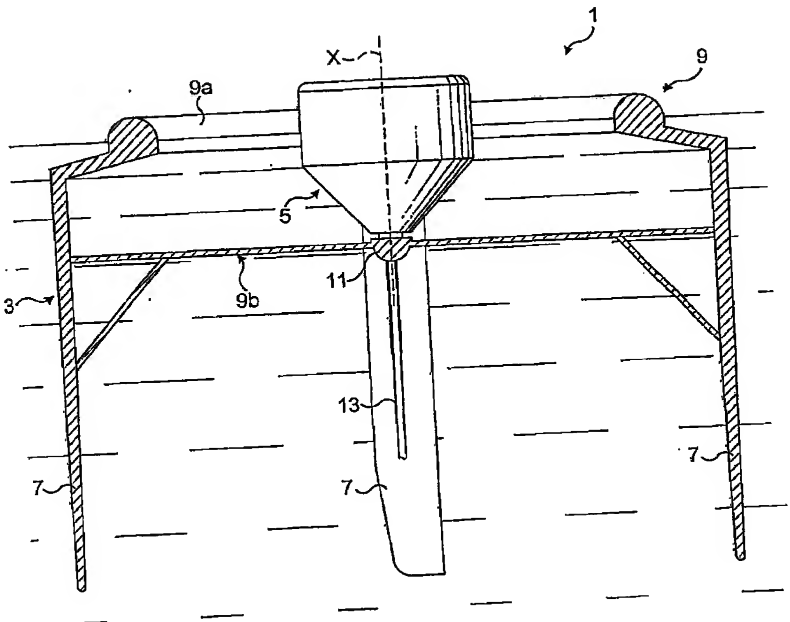


FIG. 7

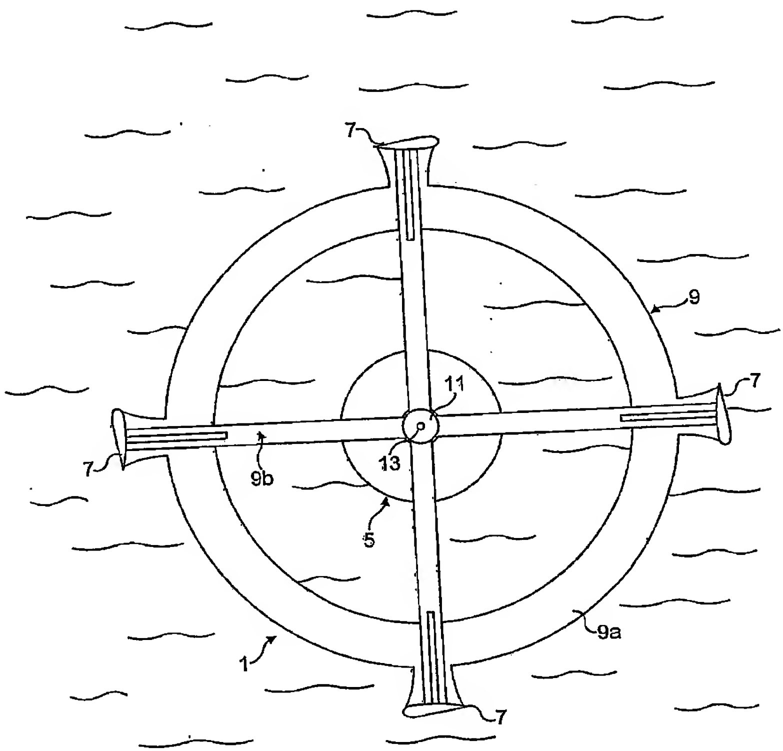


FIG. 8

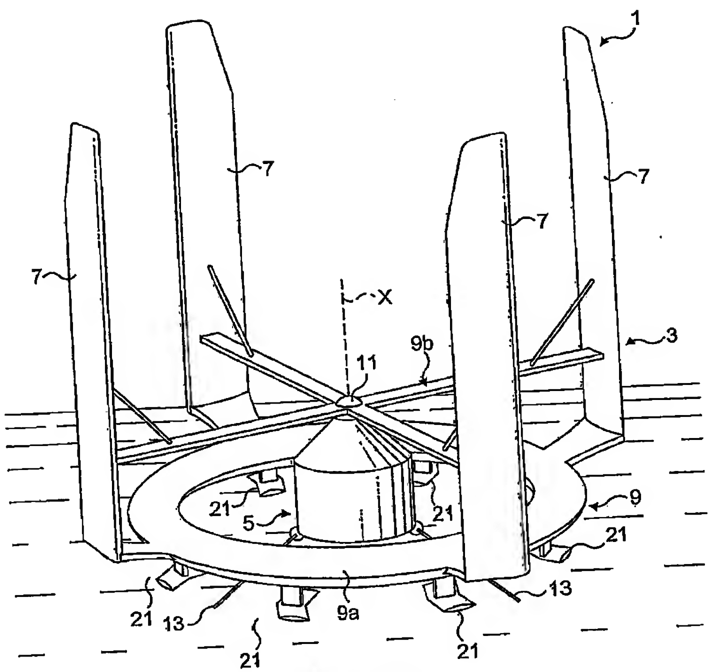


FIG. 9

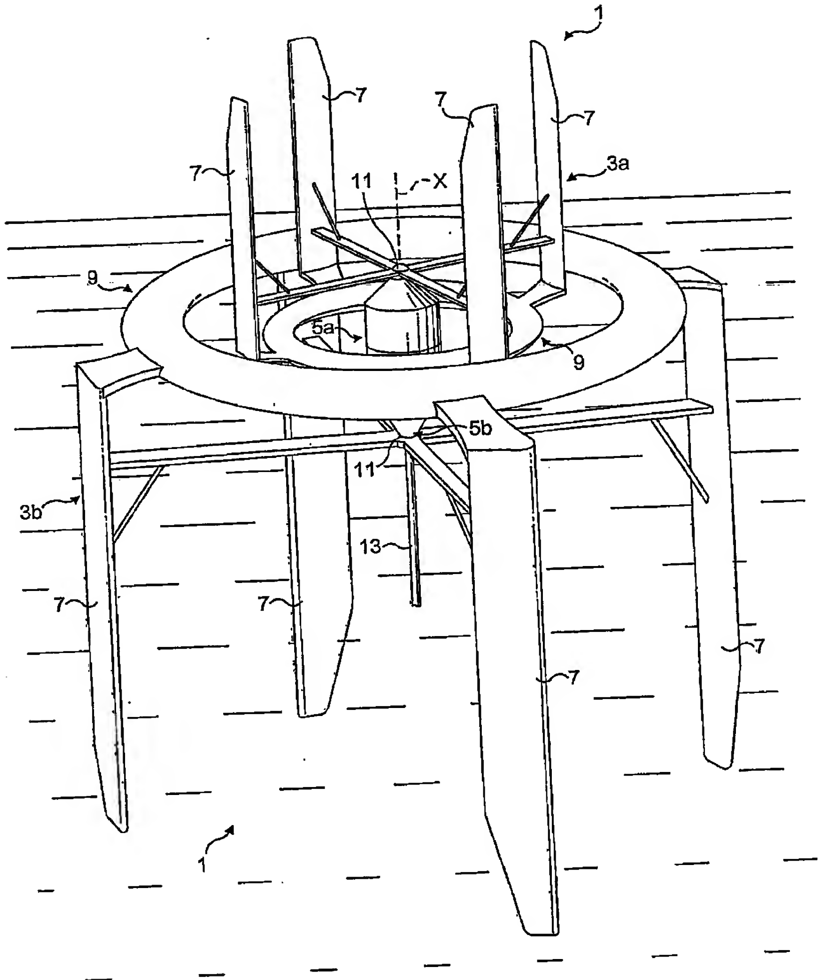


FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/03861

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03D11/04 F03B17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F03D F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 307 722 A (HUNTER JOHN) 4 June 1997 (1997-06-04) cited in the application	1-3,6, 9-11,13, 16, 19-26, 30,32,33
Y	page 3, line 25 -page 3, line 32; figures 4,5 page 5, line 33 -page 6, line 34 ———	29,31,34
X	DE 32 24 976 A (ERNO RAUMFAHRTTECHNIK GMBH) 5 January 1984 (1984-01-05) cited in the application	1-6,10, 12-16, 20-24, 29,30,32
Y	abstract page 13, line 25 -page 13, line 27; figures 5,6 ———	17
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2002	26/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Descoubes, P

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 32 09 347 A (SCHLOBIES CHRISTOPH DIPL PHYS) 15 September 1983 (1983-09-15)	1-5,7,9, 20-24, 27,29, 30,32,33
Y	the whole document	17
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 165 (M-230), 20 July 1983 (1983-07-20) & JP 58 072677 A (NIHON DENKI SEIKI KK), 30 April 1983 (1983-04-30) abstract	1-6,9, 20-23, 25,29, 30,32,33
X	RU 2 074 936 C (MAMYRIN ANATOLIJ V) 10 March 1997 (1997-03-10) & DATABASE WPI Week 9741, 10 March 1997 (1997-03-10) Derwent Publications Ltd., London, GB; AN 1997-447091 abstract	1-3,6, 20-24, 30,33
Y	PATENT ABSTRACTS OF JAPAN vol. 007, no. 169 (M-231), 26 July 1983 (1983-07-26) & JP 58 074877 A (NIPPON KOKAN KK), 6 May 1983 (1983-05-06) abstract	29
Y	DE 197 44 174 A (OTTO GERD ALBRECHT) 8 April 1999 (1999-04-08) column 2, line 59 -column 2, line 62; figures 1,9 column 3, line 8 -column 3, line 13	31
Y	US 4 099 560 A (FISCHER WILLIAM ET AL) 11 July 1978 (1978-07-11) abstract; figure 1	34
A	SE 414 074 B (LJUNGSTROM OLLE) 7 July 1980 (1980-07-07) abstract; figure 5	1-34

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/03861

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 2307722	A	04-06-1997	NONE		
DE 3224976	A	05-01-1984	DE	3224976 A1	05-01-1984
DE 3209347	A	15-09-1983	DE DE	3203397 A1 3209347 A1	11-08-1983 15-09-1983
JP 58072677	A	30-04-1983	NONE		
RU 2074936	C	10-03-1997	RU	2074936 C1	10-03-1997
JP 58074877	A	06-05-1983	NONE		
DE 19744174	A	08-04-1999	DE	19744174 A1	08-04-1999
US 4099560	A	11-07-1978	GB	1519203 A	26-07-1978
SE 414074	B	07-07-1980	CA SE	1146470 A1 7810505 A	17-05-1983 07-04-1980